

OPPORTUNITY

Windows are responsible for how much energy use?

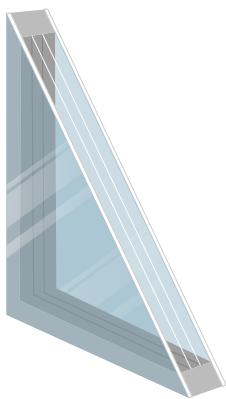
34% OF COMMERCIAL BUILDING HVAC ENERGY IS LOST THROUGH WINDOWS  
An improved building envelope minimizes HVAC loads and contributes to Net-Zero goals

TECHNOLOGY

How are Lightweight Quad-Pane Windows made?

4 PANES IN INSULATED FIBERGLASS FRAME WITH WARM-EDGE SPACERS & KRYPTON GAS

R-8 RATED FULL-FRAME INSULATING VALUE  
2 configurations: 2 outer panes of low-e glass containing either 2 panes of thin glass or 2 layers of suspended film



M&V

Where did Measurement and Verification occur?

NATIONAL RENEWABLE ENERGY LABORATORY (NREL) assessed quad-pane windows provided by Alpen High Performance Products at the Denver Federal Center. One option used thin glass and one used suspended film.

RESULTS

How did Lightweight Quad-Pane Windows perform in M&V?

24% AVERAGE HVAC SAVINGS\*  
SUSPENDED-FILM CONFIGURATION SAVED 1% MORE ENERGY THAN THIN GLASS OPTION<sup>2</sup>  
\*Compared to high-performance double-pane window

HVAC CAPITAL SAVINGS  
REDUCES REQUIRED SIZE OF HVAC EQUIPMENT; MODELING ESTIMATES \$120K IN EQUIPMENT SAVINGS FOR A 498K SF BUILDING<sup>3</sup>

SAME INSTALLATION  
IDENTICAL THICKNESS, COMPARABLE WEIGHT, ~10% MORE EXPENSIVE THAN HIGH-PERFORMING DOUBLE-PANE<sup>4</sup>

Positive Return on Investment Across Climate Zones

New construction payback < 3 years at average GSA utility rates, \$0.11/kWh and \$7.43/MMBtu<sup>5</sup>

Location		Savings from High-Performance Double-Pane to Quad-Pane Thin Glass*					
CLIMATE ZONE	CITY	HEATING kBtu/ft2/yr	COOLING kBtu/ft2/yr	FAN kBtu/ft2/yr	TOTAL %	PAYBACK* YRS	SIR positive ROI if >1
1A	Miami, FL	0 . 64	2 . 29	1 . 61	19%	1 . 7	12 . 1
2A	Dallas, TX	1 . 09	2 . 36	1 . 59	20%	1 . 5	12 . 9
2B	Phoenix, AZ	1 . 13	2 . 16	2 . 00	25%	1 . 5	13 . 3
3A	Atlanta, GA	1 . 97	2 . 31	1 . 65	24%	1 . 4	14
3B	Las Vegas, NV	1 . 54	1 . 82	2 . 08	27%	1 . 6	12 . 7
3C	San Francisco, CA	1 . 95	2 . 00	1 . 78	33%	1 . 5	13 . 1
4A	Washington, D.C.	3 . 25	2 . 48	1 . 66	28%	1 . 3	15 . 5
5A	Chicago, IL	4 . 40	0 . 56	1 . 21	23%	2 . 5	7 . 9
5B	Ogden, UT	3 . 62	0 . 68	1 . 43	23%	2 . 4	8 . 3
6A	Minneapolis, MN	4 . 96	0 . 55	1 . 17	20%	2 . 5	8 . 1
AVERAGE SAVINGS		2 . 46	1 . 72	1 . 62	24%	1 . 8	11 . 8

\*Optimized for climate zones: 1A-3C SHGC 0.20, 1A-3C SHGC 0.46.  
\$32.38/ft² double-pane \$34.87/ft² quad-pane with thin glass \$36.87/ft² quad-pane with film.  
Higher-efficiency windows can reduce HVAC capacity requirements and should be factored into the economics of any new construction or major renovation project.

DEPLOYMENT

Where does M&V recommend deploying Lightweight Quad-Pane Windows?

ALL NEW CONSTRUCTION  
END-OF-LIFE WINDOW REPLACEMENT

Thin-glass configuration is more cost-effective. Suspended-film version offers versatility in low-e coatings, meets tempered glass requirements, and is about 1 lb lighter per square foot than the thin-glass configuration.

<sup>1</sup>Low-e Applied Film Window Retrofit for Insulation and Solar Control, Charlie Curcija, Howdy Goudey, Robin Mitchell, LBNL, February 2017, p. 10  
<sup>2</sup>Demonstration and Evaluation of Lightweight High Performance Quad-pane Windows , Kosol Kiatreungwattana, Lin Simpson (NREL), October 2021, p.17 <sup>3</sup>Ibid, p.28 <sup>4</sup>Ibid, p.28 <sup>5</sup>Ibid, p.21